The legends and myths of nanotechnologies: what is a real nature of elastic properties of nanocrystallites

Stankov, S.; Yue, Yuanzheng; Miglierini, M.; Sepiol, B.; Sergueev, I.; Chumakov, A. I.; Hu, L.; Svec, P.; Rüffer, R.

Publication date:
2009

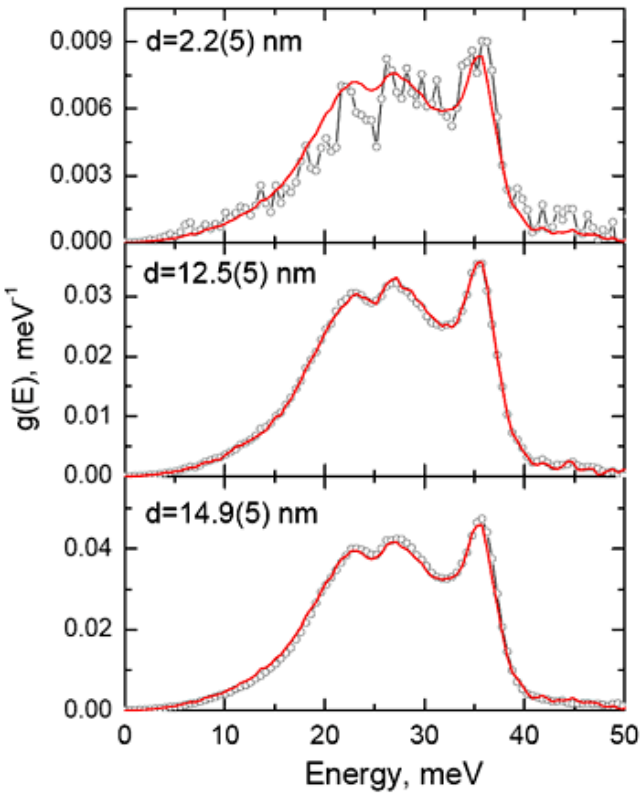
Document Version
Publisher's PDF, also known as Version of record

THE LEGENDS AND MYTHS OF NANOTECHNOLOGIES: WHAT IS A REAL NATURE OF ELASTIC PROPERTIES OF NANOCRYSTALLITES

S. Stankov[1,†], Y.Z. Yue[2,3], M. Miglierini[4], B. Sepiol[5], I. Sergueev[1], A.I.Chumakov[1,6,‡], L. Hu[2,3], P. Svec[7], and R. Rüffer[1]

[1]*European Synchrotron Radiation Facility, Grenoble, France*
[2]*Section of Chemistry, Aalborg University, Aalborg, Denmark*
[3]*Key Laboratory of Liquid Structure and Heredity of Materials, Shandong University, Jinan, China*
[4]*Department of Nuclear Physics and Technology, Slovak University of Technology, Bratislava, Slovakia*
[5]*Faculty of Physics, University of Vienna, Vienna, Austria*
[6]*Russian Scientific Center "Kurchatov Institute", Moscow, Russia*
[7]*Institute of Physics, Slovak Academy of Sciences, Bratislava, Slovakia*
[‡]*chumakov@esrf.fr*

Nanocrystalline materials have already played an important role in mankind's history, their use ranging from ancient Damascan swords to modern lithium batteries. Today the physics of nanocrystalline solids continues to attract growing interest due to their extraordinary properties such as enhanced hardness, enlarged plasticity, and superior magnetic properties. Since the elastic properties are tightly related to the lattice dynamics, clear understanding of the atomic vibrations in nanocrystalline materials is important. A key characteristic of atomic dynamics is the density of phonon states (DOS), which gives a frequency spectrum of atomic vibrations and provides a complete description of the elastic and thermodynamic properties. The experimentally-determined DOS of nanocrystalline systems reveals striking anomalies such as broadening of the phonon peaks and enhancement of the phonon states at low and high energies. These anomalies are generally believed to result from atoms at the nanograin surface, which can amount to ~65% of the volume for a grain of 2 nm in size.



Contrary to the general believes, we found [1] that the atomic vibrations in nanograins are actually identical to those in the bulk even for extremely small grain sizes *d* (Fig.1). The anomalous dynamics of nanocrystalline materials arises in fact from the atomic vibrations in the disordered interfaces.

[†]presently at Institut für Synchrotronstrahlung (ISS), Forschungszentrum, Karlsruhe, Germany.

[1] S. Stankov, Y.Z. Yue, M. Miglierini, B. Sepiol, I. Sergueev, A.I. Chumakov, L. Hu, P. Svec, and R. Rüffer. Phys. Rev. Lett. (2008), 100, p. 235503